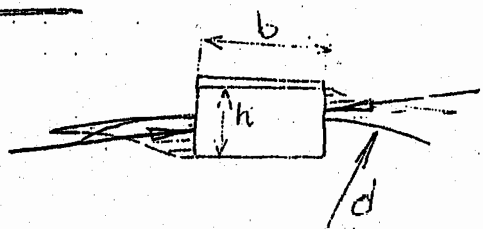
Feathers, Keys and Splines

1) **Feathers:**



$b = \frac{d}{4} + (2 \rightarrow 5)\,mm$ to get even no

$h = \frac{b}{2} + (2\text{-}3)\,mm$ to get even no

$(b = 0.25 - 0.3\,d)$

For $\phi 50$: $b = \frac{50}{4} + 3.5 = 16$, $h = \frac{16}{2} + 2 = 10$ $\Big\}$ $b \times h = 16 \times 10$

$\phi 75$	$b = 18.75 + 3.25 = 22$, $h = 11 + 2 = 13$ mm
$\phi 120$	$b = 30 + 2 = 32$, $h = 16 + 2 = 18$

Fit on sides, H/k fit (Called keying fit)

Material St. 60 $(\sigma_{y_t} = 30\ kg/mm^2)$
$(\tau_y \cong 20\ kg/mm^2)$

Length:-

Fixed $\left\{\begin{array}{l}\text{Calculated for crushing in hub (usualy CI)} \\ \text{Checked for shear.}\end{array}\right.$

Sliding $\left\{\begin{array}{l}\text{common length in contact calculated for bearing} \\ \text{pressure \& checked for shear.}\end{array}\right.$

$$\tau_{all} \leq \frac{2T}{bd\,l} \qquad \text{i.e.} \quad l \geqslant \frac{2T}{bd\,\tau_{all}}$$

For the shaft:

$$\tau_{all} \geqslant \frac{16T}{\pi d^3} \qquad \text{i.e.} \quad l \geqslant \frac{2T(\pi d^3)}{bd\,(16T)}$$

$\pi \simeq 3$, $b \simeq \frac{d}{4}$

$$\therefore l \geqslant \frac{4 \times 2 \times 3\ d^2}{16 \times d} \geqslant 1.5\,d$$

This length is based on equality of allowable shear stress of key & shaft.

Allowable Stresses:

1- Crushing :-

$\frac{\sigma_y}{2}$ of the weakest material

(800 — 1500 kg/cm²)
C.I. C.St

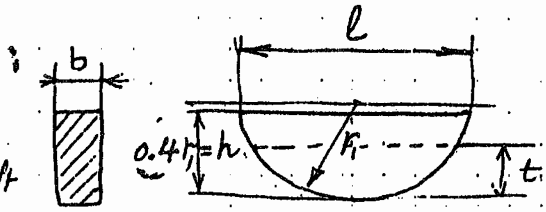
higher allowable values are accepted for steady running & light overloads.

2- Bearing pressure :-

Sliding at low speed and under load

$p = 100 - 200$ kg/cm²

2)- <u>Woodruff key</u>:

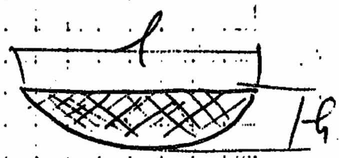


$b = 0.15 - 0.2\ d_{shaft}$

if $t\ (\simeq 0.6h)$ is more than $\frac{1}{3} d_{sh}$, use another connection

Calalated mainly for crushing in the hub. Widely used in automotive industries. Usualy used to transmit part of the power transmitted by the shaft.

$l = (0.92 \rightarrow 0.98)\, d.$

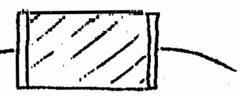


Area $= \frac{h}{6s}\,(3h^2 + 4s^2)$

3) Taper keys:

- Saddle
- On flat
- Sunk

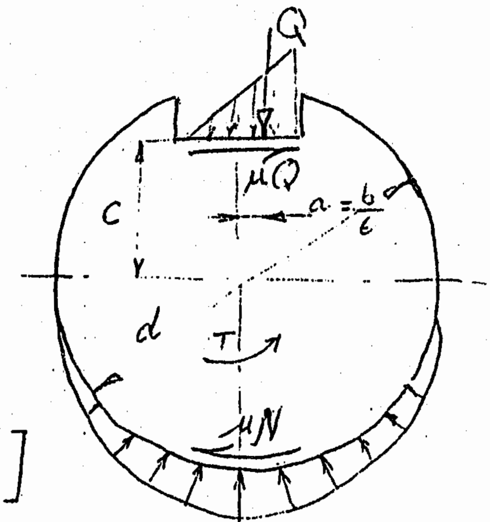
} Tangential ~~keys~~



Taper 1:100 metric & $\frac{1}{8}''$ per foot in English systems which is equivalent to 1:96

Sunk key:

$$T \leq Qa + \mu Q c + \mu N \frac{d}{2}$$



let $c \simeq 0.5d$

$a = \frac{b}{6}$

$N = \frac{4}{\pi} Q$

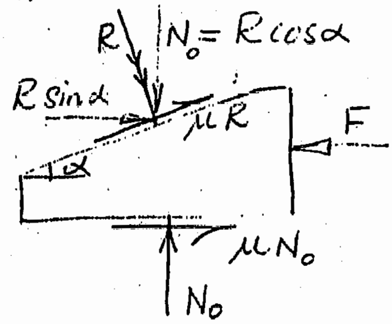
& $Q = 0.5\, b\, l\, \sigma_{cr}$ distribution factor

$$\therefore T \leq Q\left[a + \mu c + \frac{2\mu d}{\pi}\right]$$

$$\leq \frac{bl}{2}\left[\frac{b}{6} + \frac{\mu d}{2} + \frac{2\mu d}{\pi}\right]\sigma_{cr} \qquad N = \frac{4}{\pi} Q$$

$$\leq \frac{bl}{12}\left[b + 3\left(1 + \frac{4}{\pi}\right)\mu d\right]\sigma_{cr}$$

Driving force:



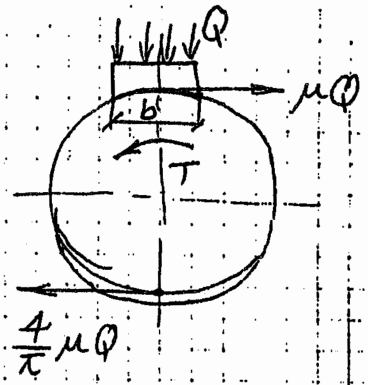
$$F = \mu N_o + R\sin\alpha + \mu R\cos\alpha$$

$$= \mu N_o + N_o \frac{\sin\alpha}{\cos\alpha} + \mu N_o$$

$$= N_o\left[\tan\alpha + 2\mu\right], \qquad N_o = Q$$

$$Q = N_o = \frac{T}{\left[a + \mu c + \frac{2\mu}{\pi} d\right]}$$

Saddle key:



$$T \leq \mu Q \frac{d}{2}\left[1 + \frac{4}{\pi}\right]$$

$$\text{i.e } T \leq \mu Q \frac{d}{2}(2.28)$$
$$\leq 1.14\ \mu Q d$$

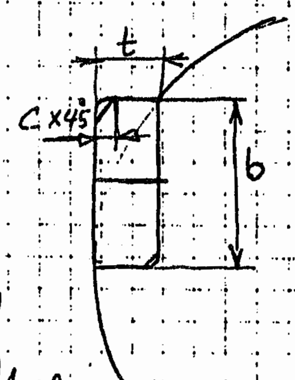
l by check for crushing with hub:

$$\sigma_{cr} \leq \frac{Q}{b\,l} \quad \text{i.e } l \geq \frac{Q}{b\,\sigma_{cr}}$$

Key on flat:-

The same as the sunk key.

Tangential keys:



$$T \leq Q\frac{d-t}{2} + \frac{4}{\pi}\mu Q \frac{d}{2}$$

let $t \cong 0.1d$, $Q \leq (t-c)\,l\,\sigma_{cr}$

$$\therefore T \leq \left(0.45 + \frac{2\mu}{\pi}\right) d\, l\,(t-c)(\sigma_{cr})$$

Two sets in opposite position 120° apart to allow for transmition in two directions of rotation.

In heavy duty $t = 0.1d$, $b = 0.3d$

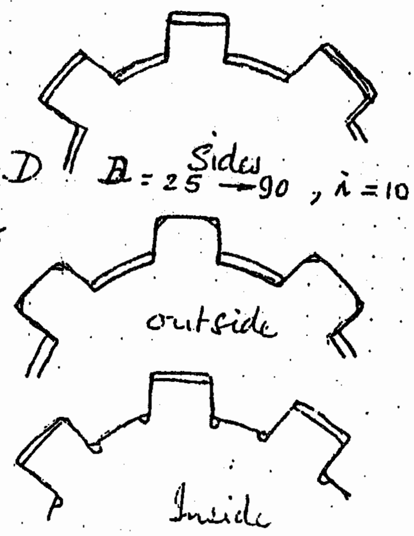
Std key joints
$t = 0.115d \rightarrow 0.066d$
$b = 0.32d \rightarrow 0.248d$
small "d"; large "d"

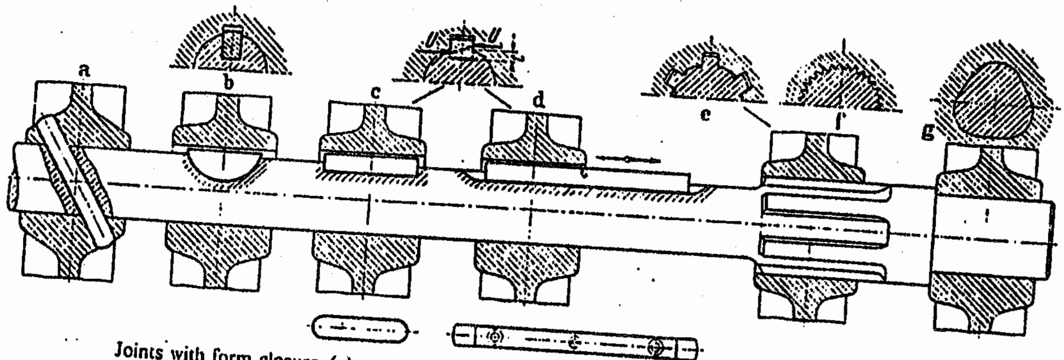
4) Splines

4-1- Parallel sides

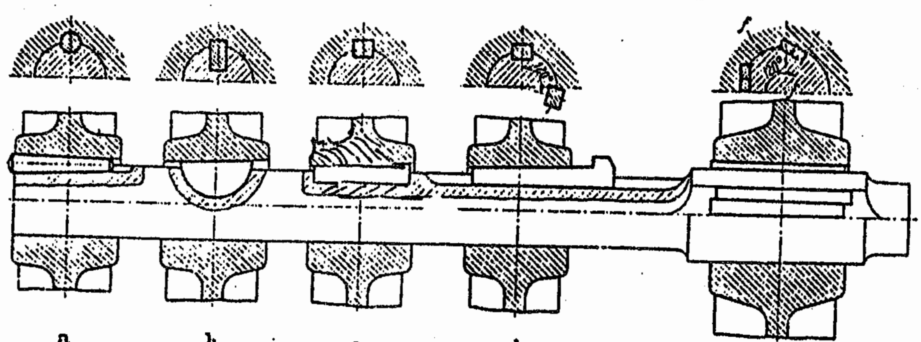
less accu., high Capacity →

- Fit on sides
- Fit on outside D
- Fit on inside d

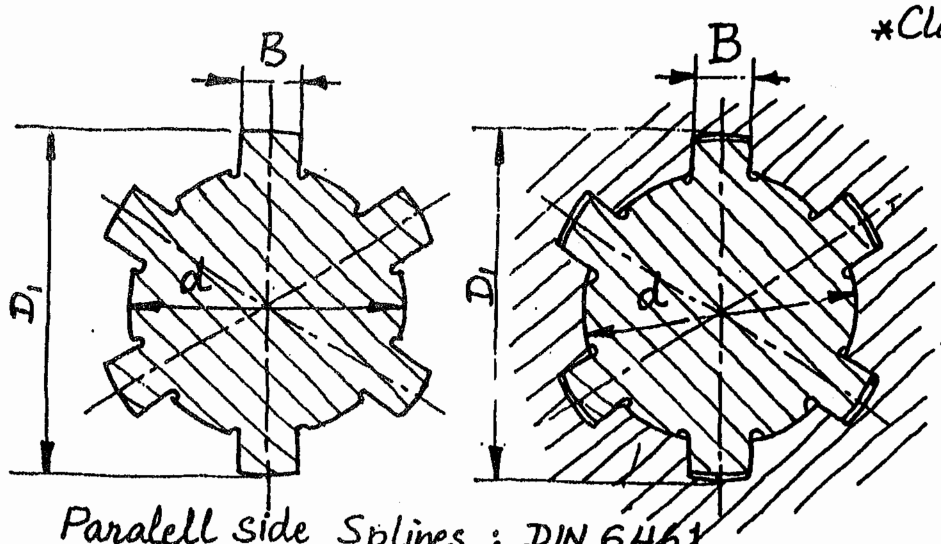




Joints with form closure, (a) transverse pin, (b) woodruff key, (c) laid in feather key (parallel key), (d) sliding feather key, (e) splined profile, (f) serrated tooth profile, (g) K-profile.



Pre-stressed joint with form closure, (a) round taper key (end key), (b) tapered woodruff key, (c) sunk taper key, (d) driven taper key with or without gib head (at 120° to each other if two keys are used), (e) tangential key (f—f = position of parting line) when the hub is split.



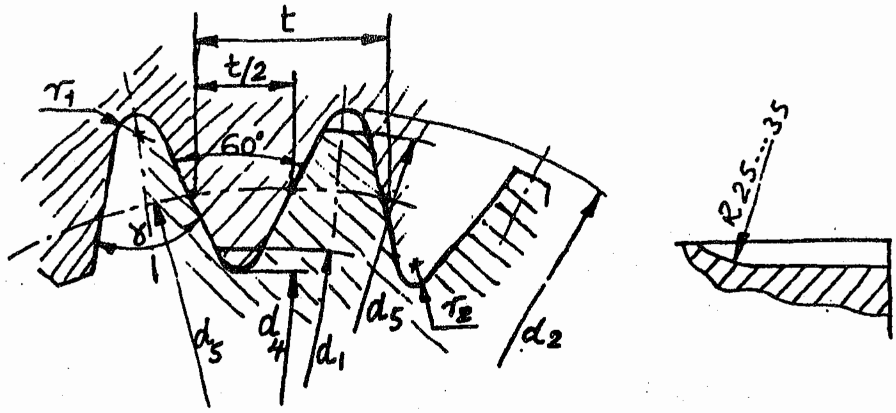
*Class of Fit on d :

- For light series: H_7/f_7.
- For Medium series: H_7/g_7
- For Heavy series: H_7/h_7

* For other tolerances in details, See DIN 5465

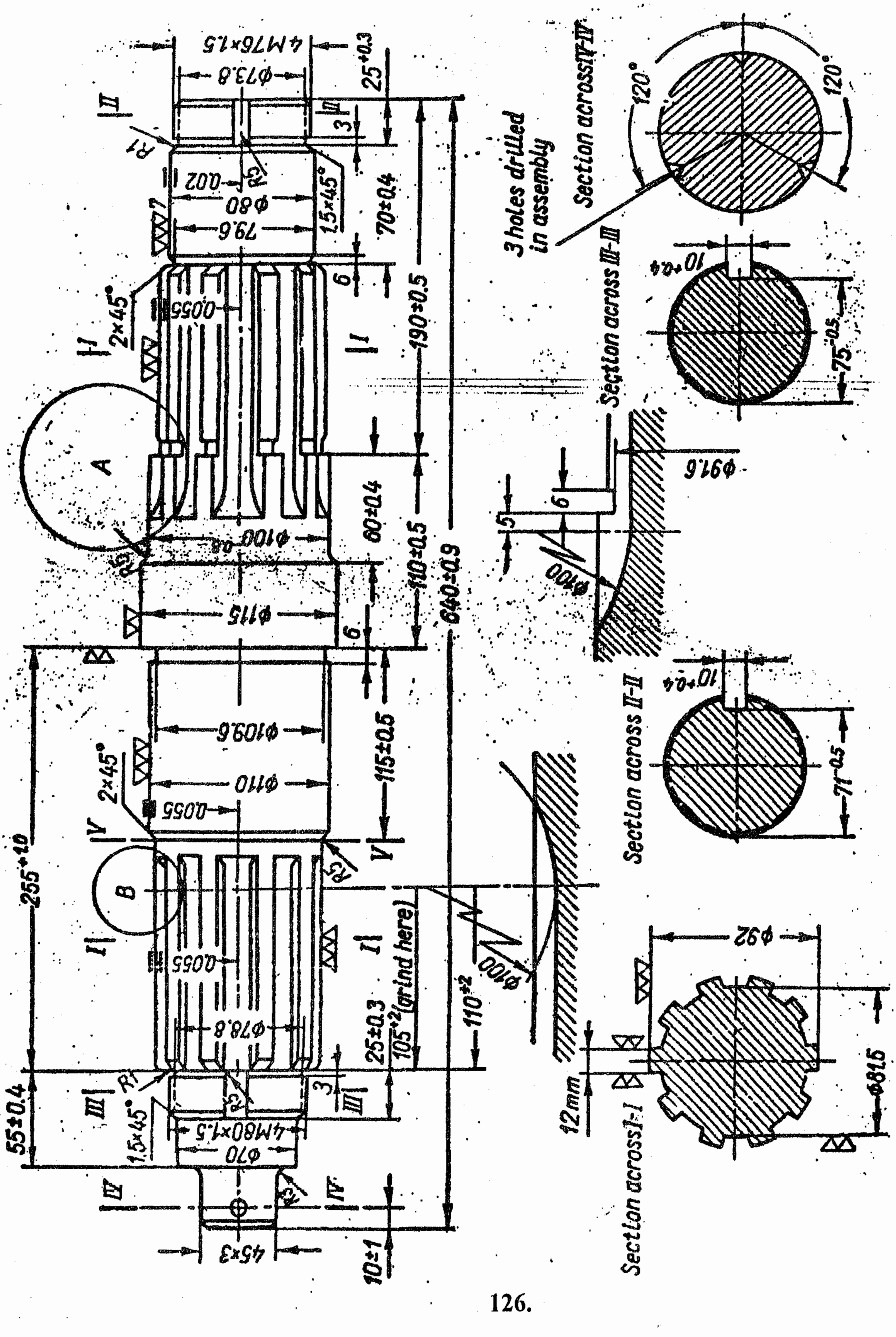
Paralell side Splines : DIN 6461

Inner d	Nº of Splines	Light Series DIN 5462		Medium Series DIN 5463		Nº of Splines	Heavy Series DIN 5464	
		D_1	B	D_1	B		D_1	B
16	6			20	4	10	20	2.5
18				22	5		23	3
21				25	5		26	3
23		26	6	28	6		29	4
26		30	6	32	6		32	4
28		32	7	34	7		35	4
32	8	36	6	38	6		40	5
36		40	7	42	7		45	5
42		46	8	48	8		52	6
46		50	9	54	9		56	7
52		58	10	60	10	12	60	5
56		62	10	65	10		65	5
62		68	12	72	12		72	6

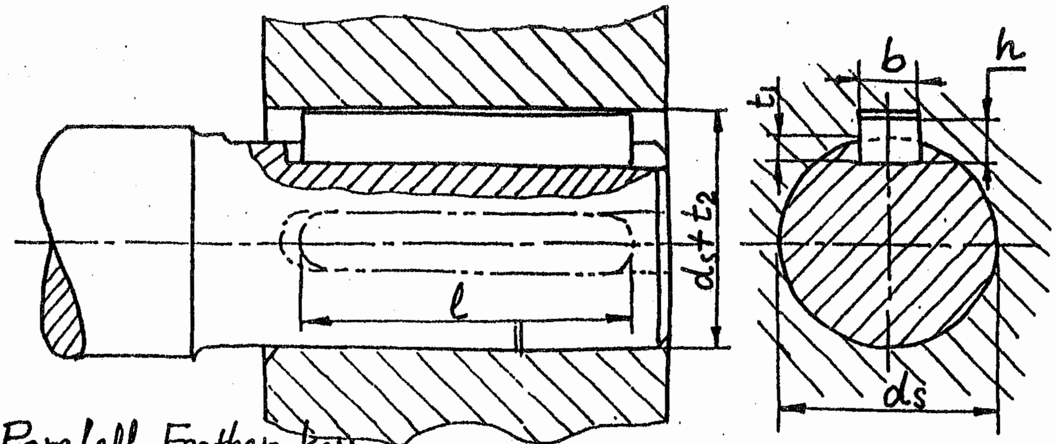


Serrations , DIN 5481

$(d_1 \times d_3)$ ϕ	d_1 (A11)	d_2	d_3 (a11)	d_4	d_5	r_1 ≈	t (measured on d_5)	z
10 x 12	10.1	12	12	10.2	11	0.1	1.152	30
12 x 14	12	14.18	14.2	12.06	13	0.1	1.317	31
15 x 17	14.9	17.28	17.2	14.91	16	0.15	1.571	32
17 x 20	17.3	20	20	17.37	18.5	0.15	1.761	33
21 x 24	20.8	23.76	23.9	20.76	22	0.15	2.033	34
26 x 30	26.5	30.06	30	26.40	28	0.25	2.513	35
30 x 34	30.5	34.17	34	30.38	32	0.3	2.792	36
36 x 40	36	40.16	39.9	35.95	38	0.5	3.226	37



3 holes drilled in assembly
Section across IV-IV
Section across III-III
Section across II-II
Section across I-I
(grind here)
4M76×1.5
4M80×1.5
640±0.9

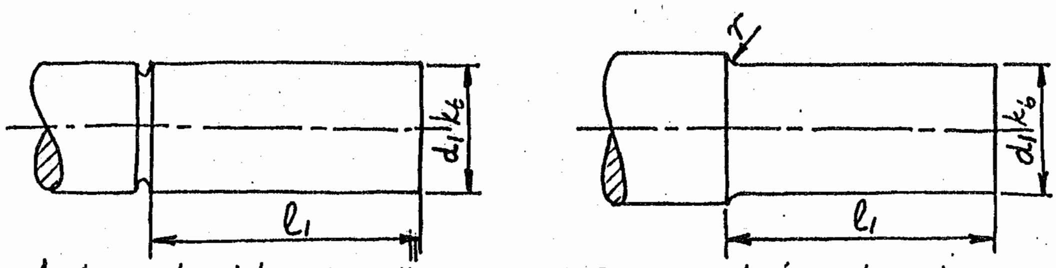


Paralell Feather key:

(Extracted From DIN 6885 Table 1)

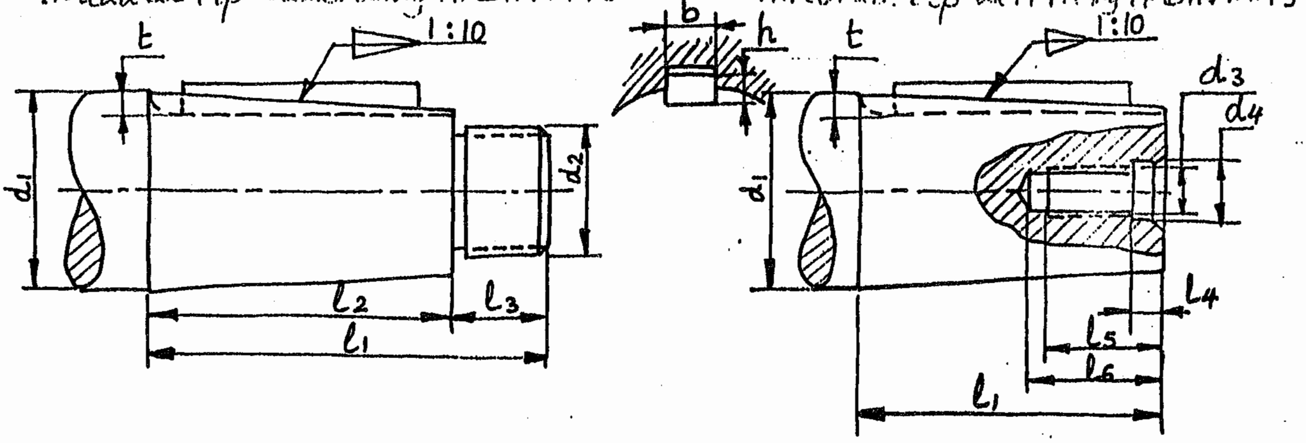
d_s From	d_s Up to	b	h	t_1	t_2	l From	l Up to
6	8	2	2	1.2	1	6	20
8	10	3	3	1.8	1.4	6	36
10	12	4	4	2.5	1.8	8	45
12	17	5	5	3	2.3	10	56
17	22	6	6	3.5	2.8	14	70
22	30	8	7	4	3.3	18	90
30	38	10	8	5	3.3	22	110
38	44	12	8	5	3.3	28	140
44	50	14	9	5.5	3.8	36	160
50	58	16	10	6	4.3	45	180
58	65	18	11	7	4.4	50	200
65	75	20	12	7.5	4.9	56	210
75	85	22	14	9	5.4	63	250
85	95	25	14	9	5.4	70	280
95	110	28	16	10	6.4	80	320

* Cylindrical shaft ends according to DIN 748-1



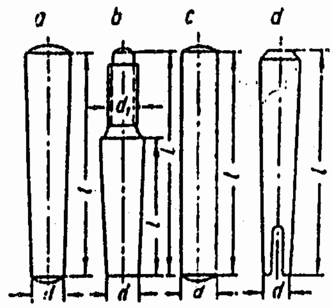
* Tapered shaft end with externally threaded tip according to DIN 1448

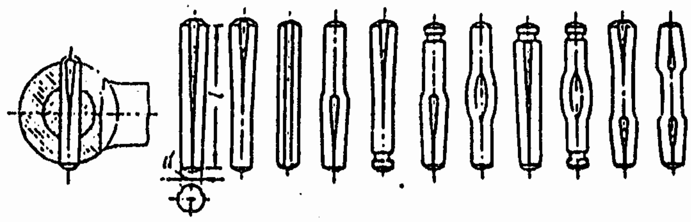
* Tapered shaft end with internally threaded tip according to DIN 1449

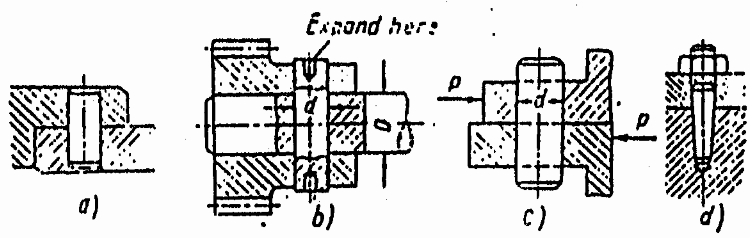


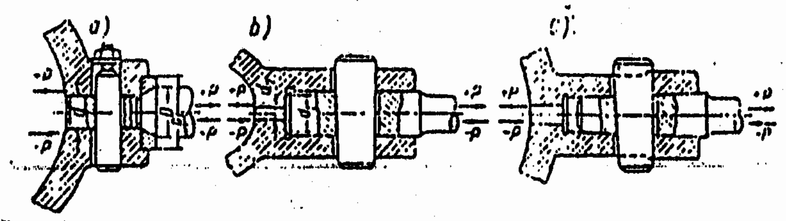
d_1	l_1 Long	l_1 Short	l_2 Long	l_2 Short	l_3	l_4	l_5	l_6 min.	r max.	t Long	t Short	b×h	d_2	d_3	d_4
12	30	18	18	—						1.7	—	2x2			
14					12	3.2	10	14		2.3	—		M8 x 1	M 4	4.3
16										2.5	2.2	3x3			
19	40	28	28	16		4	12.5	17	0.6	3.2	2.9		M10x1.25	M 5	5.3
20															
22	50	36	36	22	14	5	16	21		3.4	3.1	4x4	M12x1.25	M6	6.4
24										3.9	3.6				
25															
28	60	42	42	24	18	6	19	25		4.1	3.6	5x5	M16x1.5	M8	8.4
30										4.5	3.9				
32						7.5	22	30					M20x1.5	M 10	10.5
35	80	58	58	36	22				1	5	4.4	6x5			
38															
40						9.5	28	37.5					M24x2	M12	13
42												10x8			
45	110	82	82	54	28					7.1	6.4				
48						12	36	45				12x8	M30x2	M16	17
50									1.6				M36x3		

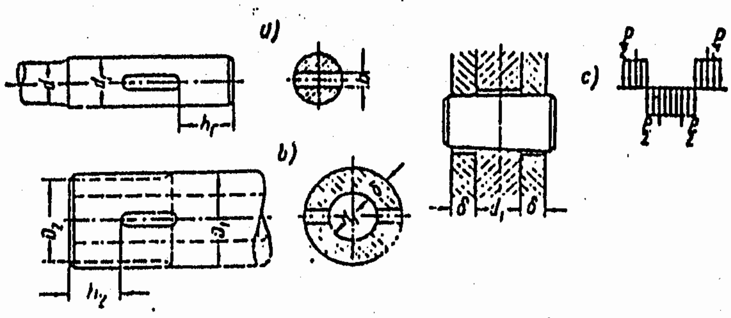
Pins and Cotters

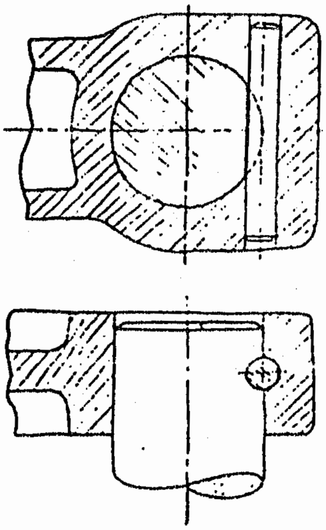


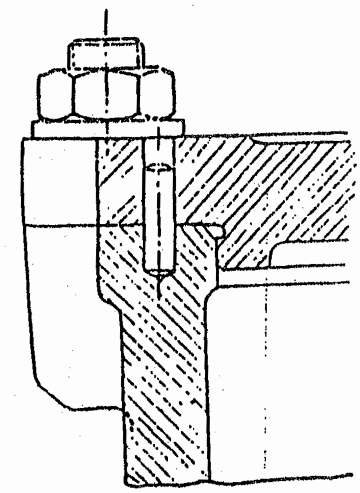


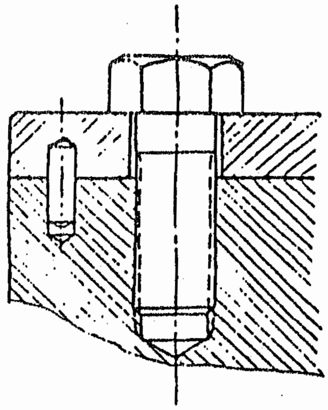


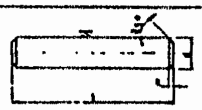




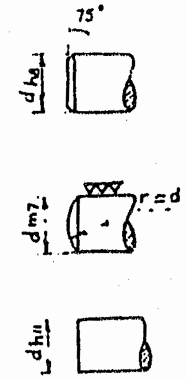




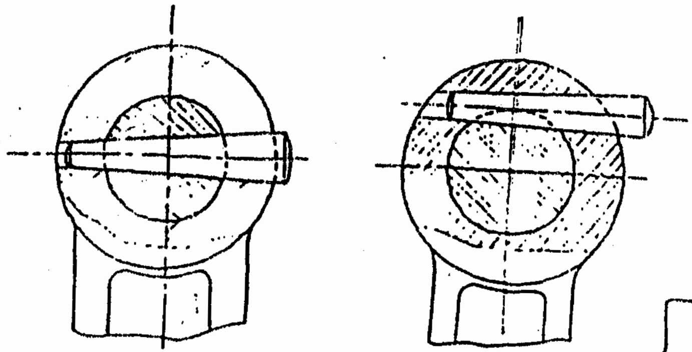


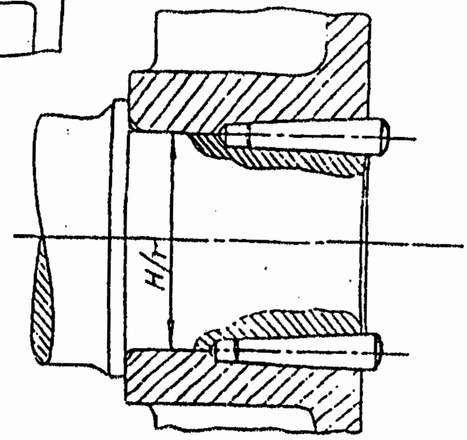


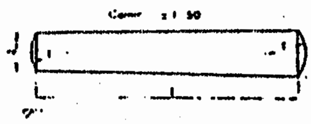
PARALLEL PINS



d	L														a
2	5	6	8	10	12	14	16	18	20						0,4
3	8	10	12	14	16	18	20	22	25	28	30	32	35	38	0,6
	40	45	50												
4	8	10	12	14	16	18	20	22	25	28	30	32	35	38	0,6
	40	45	50												
5	10	12	14	16	18	20	22	25	28	30	32	35	38	40	1
	45	50	55	60											
6	12	14	16	18	20	22	25	28	30	32	35	38	40	45	1
	50	55	60	65	70										
8	16	18	20	22	25	28	30	32	35	38	40	45	50	55	1
	60	65	70	75	80	85	90								
10	20	22	25	28	30	32	35	38	40	45	50	55	60	65	1,5
	70	75	80	85	90	95	100								
12	25	28	30	32	35	40	45	50	55	60	65	70	75	80	1,5
	85	90	95	100	105	110	115	120	125	130	135	140			
14	28	30	35	40	45	50	55	60	65	70	75	80	85	90	1,5
	95	100	105	110	115	120	125	130	135	140	145	150	160		
16	30	35	40	45	50	55	60	65	70	75	80	85	90	95	1,5
	100	105	110	115	120	125	130	135	140	145	150	160	170	180	
18	35	40	43	50	53	60	65	70	75	80	85	90	95	100	2,5
	105	110	115	120	125	130	135	140	145	150	160	170	180		
20	40	45	50	55	60	65	70	75	80	85	90	95	100	105	2,5
	110	115	120	125	130	135	140	145	150	160	170	180	190	200	
22	40	45	50	55	60	65	70	75	80	85	90	95	100	105	2,5
	110	115	120	125	130	135	140	145	150	160	170	180	190	200	
25	45	50	55	60	65	70	75	80	85	90	95	100	105	110	2,5
	115	120	125	130	135	140	145	150	160	170	180	190	200		
28	50	55	60	65	70	75	80	85	50	95	100	105	110	115	2,5
	120	125	130	135	140	145	150	160	170	180	190	200			





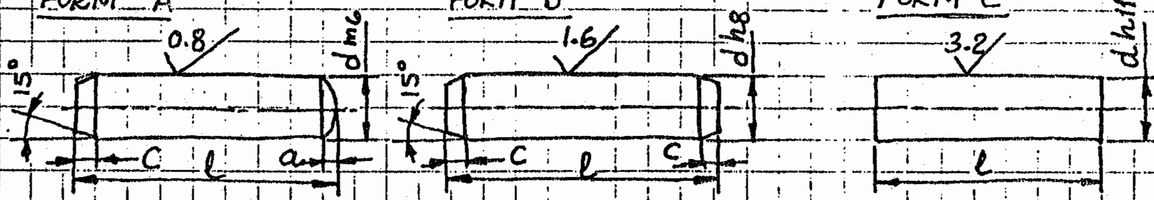


TAPER PINS

d	r	L																				
1	1,5	8	10	12	14	16	10															
1,5	1,5		10	12	14	16	18	20	22	25												
2	2,5			12	14	16	18	20	22	25	28	30	32	35								
2,5	2,5			12	14	16	10	20	22	25	28	30	32	35	38	40						
3	4				14	16	18	20	22	25	28	30	32	35	38	40	45	50				
4	4					16	18	20	22	25	28	30	32	35	38	40	45	50	55	60		
5	6							20	22	25	28	30	32	35	38	40	45	50	55	60	70	80
6	6	25	28	30	32	35	38	40	45	50	55	60	70	80	90	100						
8	10		28	30	32	35	38	40	45	50	55	60	70	80	90	100	110	120	130	140		
10	10				32	35	38	40	45	50	55	60	70	80	90	100	110	120	130	140	150	165
13	15	38	40	45	50	55	60	70	80	90	100	110	120	130	140	150	165	180	200	220		
16	20		40	45	50	55	60	70	80	90	100	110	120	130	140	150	165	190	200	220		
20	20				50	55	60	70	80	90	100	110	120	130	140	150	165	180	200	220	250	280
25	30					55	60	70	80	90	100	110	120	130	140	150	165	180	200	220	250	280
30	30						60	70	80	90	100	110	120	130	140	150	165	190	200	220	250	280

Cylinderical Pins DIN EN ISO 2338

FORM "A" FORM "B" FORM "C"

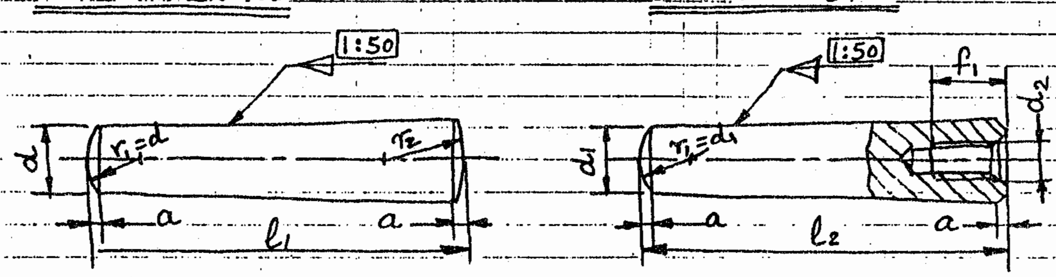


ISO 2338 - A - 5x20 - St.

ϕ d	1.2	1.5	2	2.5	3	4	5	6	8	10	12	16
l	4 12	4 16	6 20	6 24	8 32	8 40	10 50	12 60	14 80	18 95	22 140	26 180

Taper Pins

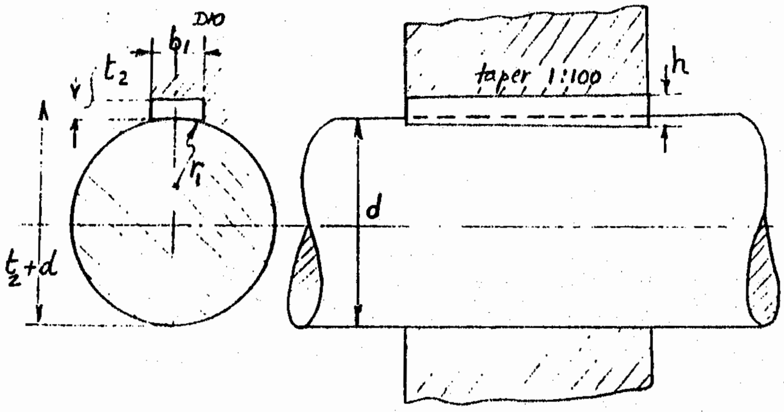
DIN EN 22339 DIN EN 28736

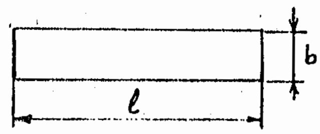


ϕ d/h10	1.5	2	2.5	3	4	5	6	8	10	12	16	20	25
a	0.2	0.25	0.3	0.4	0.5	0.6	0.8	1	1.2	1.6	2	2.5	3
l_1	8 24	10 35	10 35	12 45	14 55	18 60	22 90	22 120	26 150	32 180	40 200	45 200	50 200

$$r_2 = \frac{a}{2} + d + \frac{(0.02\ l)^2}{8a}$$

d	b	h	l
22 30	8	3.5	20 90
30 38	10	4	25 110
38 44	12	4	32 140
44 50	14	4.5	40 160
50 58	16	5	45 180
58 65	18	5	50 200
65 75	20	6	56 220
75 85	22	7	63 250



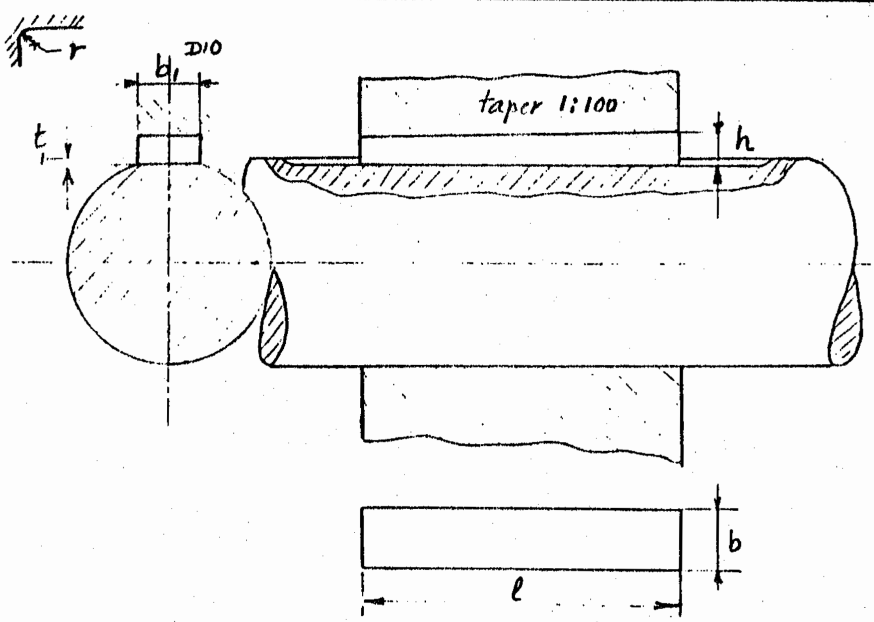


Saddle key

DIN 6881

$d > 22 \cdots 150$ mm

l = 20, 22, 25, 28, 32, 36, 40, 45, 50, 56, 63, 70, 80, 90, 100, 110, 125, 140, 160, 180, 200, 220, 250, 280, 315



d	t_1	t_2	r_1/r
22 30	1.3	3.2	15/0.4
30 38	1.8	3.7	19/0.4
38 44	1.8	3.7	22/0.5
44 50	1.4	4	25/0.5
50 58	1.9	4.5	29/0.5
58 65	1.9	4.5	33/0.5
65 75	1.9	5.5	38/0.6
75 85	1.8	6.5	43/0.6

Key on flat

Mat. St. 60

DIN 6881

$d > 22 \cdots 230$ mm

Key Size (b×h×l)

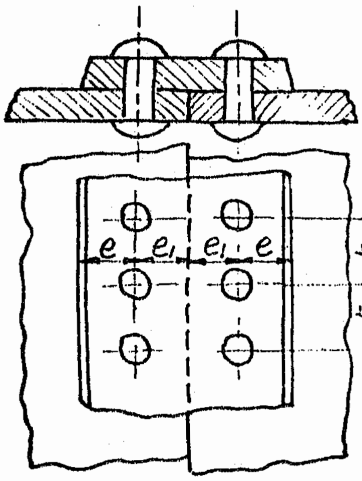
Rivets dimensions according to DIN 660, DIN 661

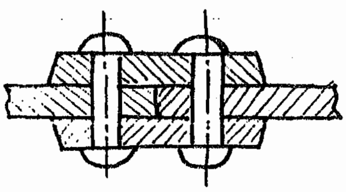
Neck diam.	d_1	1	1.2	(1.4)	1.6	2	2.5	3	3.5	4	5	6	(7)	8
Head diam	d_2	1.8	2.1	2.4	2.8	3.5	4.4	5.2	6.2	7	8.8	10.5	12.2	14
Min. tip diam	d_3	0.93	1.13	1.33	1.52	1.87	2.37	2.87	3.37	3.87	4.82	5.82	6.82	7.76
Neck Length	e	0.5	0.6	0.7	0.8	1	1.3	1.5	1.8	2	2.5	3	3.5	4
Through hole - diam	$d_7\ H_{12}$	1.05	1.25	1.45	1.65	2.1	2.6	3.1	3.6	4.2	5.2	6.3	7.3	8.4
Button headed rivet	d_8	1.8	2.1	2.4	2.8	3.5	4.4	5.2	6.2	7	8.8	10.5	12.2	14
	k_1	0.6	0.7	0.8	1	1.2	1.5	1.8	2.1	2.4	3	3.6	4.2	4.8
	$r_1 \approx$	1	1.2	1.4	1.6	1.9	2.4	2.8	3.4	3.8	4.6	5.7	6.6	7.5
Countersunk headed rivet	d_8	1.8	2.1	2.4	2.8	3.5	4.4	5.2	6.2	7	8.8	10.5	12.2	14
	$k_2 \approx$	0.4	0.5	0.6	0.7	0.8	1	1.3	1.4	1.9	2.4	2.8	3.3	3.9
	t_1	0.4	0.5	0.6	0.7	0.8	1	1.3	1.4	1.8	2.3	2.7	3.2	3.7

Protruding length $= \Delta l$

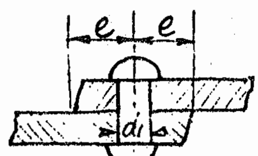
- Form A, $\Delta l = 1.8\,d$ i.e $l \geqslant s + 1.8\,d$
- Form B, $\Delta l = 1.5\,d$ i.e $l \geqslant s + 1.5\,d$

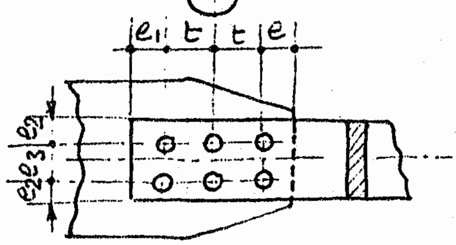
Std. Lengths:
2, 3, 4. 5, 6, 8, 10, 12, 14, 16, 18, 20, 22, 25, 28, 30, 32, 35, 38, 40



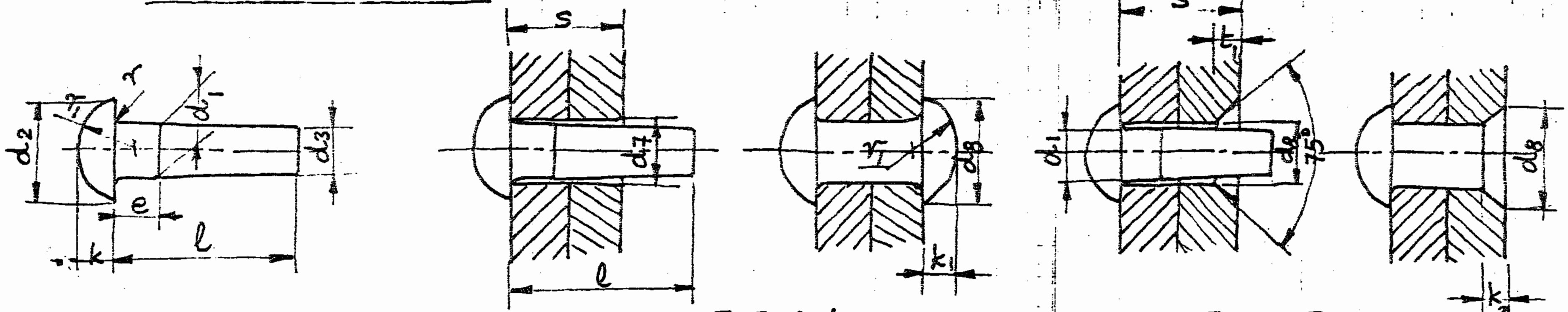


$t = 3.0 - 3.5\,d_1$
$e_1 = 2.0 - 2.5\,d_1$
$e_2 = 1.5 - 2.0\,d_1$
$e_3 = 3.0 - 3.5\,d_1$



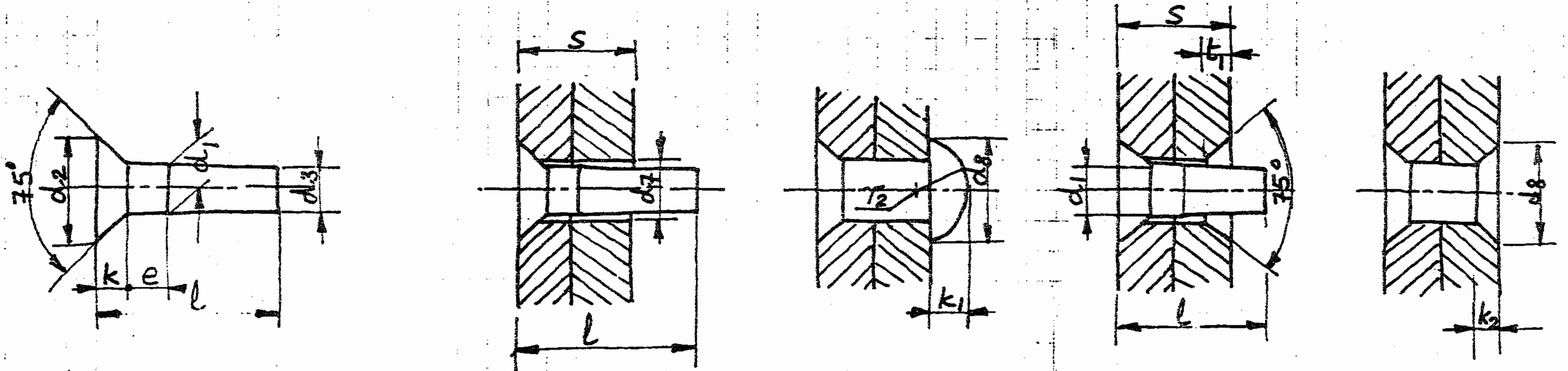


Button headed rivet DIN 660



FORM A FORM B

Countersunk headed rivet DIN 661 (July 1977)



FORM A FORM B